IJSPT

ORIGINAL RESEARCH

TEST-RETEST RELIABILITY OF THE CLOSED KINETIC CHAIN UPPER EXTREMITY STABILITY TEST (CKCUEST) IN A MODIFIED TEST POSITION IN DIVISION I COLLEGIATE BASKETBALL PLAYERS

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ABSTRACT

Background: The closed kinetic chain upper extremity stability test (CKCUEST) as originally described may not be appropriate for assessing athletes interchangeably considering body size variations. A modified test position may be warranted to normalize the CKCUEST to body size, in order to reflect an accurate representation of upper limb function.

Purpose: To determine test-retest reliability of the CKCUEST in a modified test position in Division I collegiate basketball players.

Study Design: Test-retest reliability

Methods: 15 subjects (8 male, 7 female) were recruited from Division I basketball teams. Subjects began in a push-up position with their hands located directly under their shoulders. Subjects performed one 15 second trial of the modified CKCUEST initially and a second trial one week later. Hand-written data was transferred to a spreadsheet for analysis using Minitab Statistical Software for comparison.

Results: Test-retest reliability was 0.88 for men's basketball, 0.79 for women's basketball, and 0.90 when both teams were combined. Test mean for men's basketball were 29.5 $\pm$ 4.78, and retest mean were 31.88 $\pm$ 4.99. Test mean for women's basketball were 24.86 $\pm$5.52, and retest mean were 26.71 $\pm$ 5.41. Test mean for both teams combined were 27.33 $\pm$ 5.5, and retest mean were 29.47 $\pm$ 5.67.

Conclusions: The CKCUEST in a modified test position is a reliable assessment tool. Results support previous findings and may contribute to injury prevention and return to sport decision-making.

Level of Evidence: 3b

Keywords: College athletes, functional testing, movement system, upper extremity

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The authors of this study declare no conflicts of interest.

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DOI: 10.26603/ijspt20200203

INTRODUCTION

The Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST) was developed by clinicians in order to provide a functional testing measure for the upper extremity. Clinicians wanted a test that would help them determine an athlete's readiness to return to sport or need to continue further physical therapy treatment.[1] The CKCUEST is commonly utilized in today's clinical practice as it is cost-efficient, simple to prepare and administer, and is a reliable assessment tool for varying patient populations.[1,2]

However, the CKCUEST as originally described by Goldbeck and Davies may not be appropriate for assessing all athletes interchangeably.[2-4] In the original test procedure all participants began the test with their hands touching parallel pieces of tape that were placed 36 inches apart.[1] This did not account for variability in shoulder width and/or arm length. As the athletic population ranges in body-build, age, gender, and type of sport they participate in, Taylor et al. determined that narrower shoulder width and/or shorter arm length placed athletes at a disadvantage when performing the original CKCUEST.[4] This was attributed to increased effort needed to stabilize the upper body and trunk in order to maintain the arms at a distance of 36 inches apart.[4] Thus a modified test position was determined and was described by placing the upper extremities in a push-up position with hands located directly under the shoulders to begin the test.[4] The parallel pieces of tape remain 36 inches apart, however these serve only as markers for cross-body reaches. The modified CKCUEST has demonstrated good test-retest, interrater reliability, and precision, and the authors established normative reference values pertaining to Division I athletes considering sport, gender, and age.[4]

Multiple studies have reported excellent test-retest reliability for the CKCUEST in the original test position across many populations as used to measure stability and power of the upper extremities.[1,5-7] Goldbeck and Davies reported test-retest reliability in collegiate males.[1] Sciascia and Uhl reported test-retest reliability in young adults averaging 30 years of age with shoulder pain and in young adults averaging 29 years of age without shoulder pain respectively.[8] Tucci et al. reported test-retest reliability in subjects with and without subacromial impingement comparing intersession and intrasession reliability respectively.[5] Lee and Kim. reported test-retest reliability in healthy Korean adults averaging 29.96 years of age, and Oliveira et al. reported test-retest reliability in healthy adolescents averaging 16.9 years of age.[2,7] Currently there is only one study that has reported test-retest reliability for the CKCUEST in the modified test position specific to collegiate club sport athletes, by Tarara et al.[9]

Multiple authors have reported normative reference values for the CKCUEST in the original test position across various populations, but few have reported normative reference values in the modified test position. In the original test position Goldbeck and Davies determined a test reference value in collegiate males.[1] Tucci et al. determined test-retest reference values in sedentary males, in active males, in males with subacromial impingement, in sedentary females, in active females, and in females with subacromial impingement.[5] Lee and Kim determined test-retest reference values in healthy Korean adults averaging 29.96 years of age.[7] Oliveira et al. determined test-retest reference values in healthy adolescents averaging 16.9 years of age.[2] Rousch et al. determined a test reference value in male collegiate baseball players,[11] and Botnmark et al. determined a test reference value in healthy young adults averaging 26.1 years of age.[12]

Currently only one study has reported normative reference values for the CKCUEST in a modified test position. Taylor et al.[4] determined a test reference value for both male and female Division I collegiate athletes including basketball, baseball, lacrosse, track and field, cross country running, volleyball, and soccer. The authors also determined reference values specific to sport and provided demographic and descriptive subject data that may be used to determine reference values specific to age, height, and weight.[4] However, evidence regarding the modified test position is still limited. Further research is warranted to support the findings determined by Taylor et al. and to provide additional evidence to support the use of a modified test position in clinical rehabilitation.

Thus, the purpose of the current study was to determine test-retest reliability of the CKCUEST in a

modified test position in Division I collegiate basketball players. As functional tests continue to develop and discrepancies in the original procedures ensue, reliability must be examined. This is to ensure accuracy when using these assessment tools to measure progress of each patient. Results of the study will be compared to normative reference values established by Taylor et al. and other studies in order to examine the current findings with specific consideration to test position and higher-level athletes. With additional evidence, clinicians may have more confidence when using the modified CKCUEST to assess an athlete's performance relative to others. This may help to identify specific upper extremity joint stability, proprioception, and kinesthesia deficits to target during training or may contribute to return to play decision-making.

METHODS

Participants

Participants were recruited from NCAA Division I basketball teams during the summer semester at the authors' institution. The prospective study was presented to each team following a scheduled practice. 15 basketball players (8 male, 7 female) agreed to participate in the study.

Athletes were included if they were 18 years of age or older, an NCAA Division I basketball player, and if they had access to a phone or computer for purposes of communication. Athletes were excluded if they were less than 18 years of age, had experienced pain or an acute injury to their upper extremity in the previous six weeks, had undergone general surgery in the previous six weeks, had undergone surgery to their upper extremity within the previous year, or were restricted from sport participation by their team physician. Exclusion criteria were determined to avoid potential risk for injury or limitation in the ability to perform the CKCUEST in a modified test position. Athletes who voluntarily agreed to participate in the study provided written informed consent, which was approved by the Institutional Review Board at Saint Francis University.

Testing Methods

Participants were tested and retested with their team following a men's basketball recovery practice or prior to a women's basketball lifting practice. Both practices were typical for off-season training programs conducted during the summer semester. Prior to the first testing session, demographic and anthropometric data pertaining to gender, age, sport, height, weight, and arm length was collected (Table 1) and followed by a description of the test. The principal and co-investigator conducted the test. Each possessed clinical experience with Division I athletes and use of functional performance testing. A verbal and demonstrated description of the test was provided by the principal investigator. Only one trial was performed at each of the two testing sessions, which were conducted approximately one week apart. Data was collected and organized using an intake data sheet, and was later hand-entered into a Microsoft Excel spreadsheet.

The Modified CKCUEST

The CKCUEST in a modified test position described by Taylor et al. was utilized for this study. Two pieces of tape were placed 36 inches apart and made parallel to each other on the floor, as described in previous studies.[1,3-4] Participants were instructed to start in a push-up position with their hands located directly under their shoulders (Figure 1a).[4] This is a modification to the original test position, where participants began with their hands touching the parallel pieces of tape 36 inches apart.[1,3] The CKCUEST in a modified test position normalizes placement of the upper extremities to each Participant, thus accounting for variability among athletic populations.[4] Start

Table 1. *Demographic characteristics means (standard deviation) of the total sample and stratified by team.*

Team	Total (n)	Age (years)	Height (inches)	Mass (lbs)	Arm Length (inches)
Men's	8	20.1 (1.5)	74.6 (4.7)	196.4 (37.0)	75.4 (4.7)
Women's	7	18.6 (0.9)	69.5 (2.1)	158.3 (11.0)	70.6 (2.5)
Combined	15	19.5 (1.4)	72.2 (4.4)	178.6 (33.5)	73.2 (4.4)

Figure 1. *(A) Absolute number of ACL injuries that occurred within each quarter of a game separated by sport. (B) Percentage of ACL injuries that occurred within each quarter of a game separated by sport.*

Table 2. *Mean (standard deviation) and test-retest reliability of the Closed Kinetic Chain Upper-Extremity Stability Test (CKCUEST)*

Team	Total (n)	Reaches		Spearman Rho Correlation
		Test	Retest	
Men's	8	29.5 (4.78)	31.9 (4.99)	0.88
Women's	7	24.9 (5.52)	26.7 (5.41)	0.79
Combined	15	27.3 (5.50)	29.5 (5.67)	0.90

positon was approved by the tester followed by a verbal cue to begin the test. Participants completed cross-body reaches alternating each hand to the contralateral piece of tape as quickly as possible during a 15 second trial (Figure 1b). Scores reflect the total number of cross-body reaches to each piece of tape using both hands.

Statistical analysis

Data were entered into a Microsoft Excel spreadsheet for organization prior to using Minitab Statistical Software (Minitab, Inc. State College, PA) for analysis. Male basketball players, female basketball players, and both teams combined were assessed using a Spearman Rho correlation to determine reliability of test and retest scores to account for a smaller population size. Descriptive statistics were used to assess demographics and anthropometric data, and to compare scores of the CKCUEST in a modified test position to male players, female players, and both teams combined (Table 2).

RESULTS

Participants

Men's and women's basketball players were recruited following a scheduled practice. Men's basketball players were tested and retested following a practice and women's basketball players were tested and retested prior to a practice. Retests were completed one week apart. Two participants that met inclusion criteria and completed testing session one were removed from the study as scheduling conflicts prevented them from participating in testing session two.

Test Results

Test-retest reliability was 0.88 for men's basketball, 0.79 for women's basketball, and 0.90 when both teams were combined. The test mean for men's basketball was 29.5 touches with a standard deviation of 4.78, and the retest scores had a mean of 31.88 touches with a standard deviation of 4.99. The test

mean for women's basketball was 24.86 touches with a standard deviation of 5.52, and the retest scores had a mean of 26.71 touches with a standard deviation of 5.41. For both teams combined, the test mean was 27.33 touches with a standard deviation of 5.5, and the retest score had a mean of 29.47 touches with a standard deviation of 5.67.

DISCUSSION

This study was conducted to assess test-retest reliability of the CKCUEST in a modified test position of NCAA Division I collegiate basketball players. In addition to comparing results to normative reference values for the modified position established by Taylor et al. this study adds to the evidence that supports the potential use of a modified test position for the CKCUEST compared to the original description. Previous studies have developed normative reference values for the CKCUEST, however work by Taylor et al. is the only to utilize a modified test position and to establish normative reference values specific to male and female NCAA Division I collegiate athletes. As gender, sport, and skill impact performance, it is important to utilize the same testing procedures and normative reference data that are specific to the population being assessed. Thus, further research is warranted to establish the reliability of the CKCUEST in a modified test position, and to support normative reference values specific to higher-level athletes proposed by Taylor et al. This may improve use of the test as an injury predictor during baseline testing and as a sideline screen, or to determine readiness for return to play.[1,4]

Previous authors have reported test-retest reliability of the CKCUEST as originally described, and have demonstrated excellent reliability between sessions.[1,5-7] Goldbeck and Davies created the CKCUEST as originally described to evaluate the upper extremity comparable to closed kinetic chain interventions and sport-specific demands.[1] They determined an ICC of 0.92 reflecting the average score in collegiate males.[1] Sciascia and Uhl determined an ICC of 0.86 and 0.85 reflecting the average score in young adults averaging 30 years of age with shoulder pain and in young adults averaging 29 years of age without shoulder pain respectively.[8] Tucci et al. determined an ICC range between 0.85 to 0.96, reflecting the average score in subjects with and without subacromial impingement.[5] Lee and Kim determined an ICC of 0.97 reflecting the average score in healthy Korean adults, and Oliveira et al. reported an ICC of 0.68-0.87 reflecting the average score in healthy adolescents averaging 16.9 years of age.[2,7] Currently only the study by Tarara et al has reported test-retest reliability for the CKCUEST in a modified test position, who reported an ICC of 0.73 in collegiate club sport athletes.[9]

Previous authors have reported normative reference values for the CKCUEST; however, results vary due to population, test position, number of trials performed, and number of sessions performed. In the original test position Goldbeck and Davies determined 27.8 touches as a test reference value in collegiate males.[1] Tucci et al. determined 22.67 and 25.30 touches as test-retest reference values in sedentary males, 27.97 and 31.97 touches in active males, 10.10 and 11.82 touches in males with subacromial impingement, 24.58 and 28.47 touches in sedentary females, 24.78 and 27.13 touches in active females, and 12.20 and 13.73 touches in females with subacromial impingement.[5] Lee and Kim determined 13.31 and 13.10 touches as test-retest reference values in healthy Korean adults averaging 29.96 years of age.[7] Oliveira et al. determined 25.6 and 28 touches as test-retest reference values in healthy adolescents averaging 16.9 years of age.[2] Rousch et al. determined 30.41 touches as a test reference value in male collegiate baseball players.[11] Botnmark et al. determined 19.9 touches as a test reference value in healthy young adults averaging 26.1 years of age, and Hegedus et al. determined 27.8 touches as a test reference value in general college males.[12,13] In the current study men's basketball demonstrated 29.5 and 31.88 touches as test-retest reference values, and women's basketball demonstrated 24.86 and 26.71 touches as test-retest reference values. In the current findings, the retest values exceeded the initial test values in both groups which was consistent with other authors findings.[2,5,7] This may be attributed to a small learning effect which may need to be taken into consideration when implementing the test.

Currently only one study has reported normative reference values for the CKCUEST in a modified test position. Taylor et al. determined 25.0 and

22.9 touches as a test reference values for male and female Division I collegiate athletes respectively.[4-7,13] The CKCUEST as originally described was adjusted to body size by instructing participants to place hands directly underneath their shoulders, in a push-up position, and to complete across-body reaches to each piece of tape marked 36 inches apart. This modification was suggested in order to reduce excessive stabilization efforts experienced by athletes small in stature and/or with a narrow build, thereby eliminating any disadvantage due to body size.[4] Their results indicated comparable outcomes to previous studies, however it was noted that women scored higher in the modified test position compared to the original test position.[4]

To ensure consistency and to minimize a learning effect, participants in the current study were instructed to perform one trial per each of the two testing sessions as implemented in the study by Taylor et al.[4] This is different from the original procedure described by Goldbeck and Davies which included a warm-up trial prior to three scored trials. The average of the three trials is the recorded score.[1-2,5-6] Due to variations in the way the CKCUEST is implemented, the current results may not compare to the all reference values that are available.

Results of the current study including (test-retest values for men's basketball as 29.5 and 31.88 touches; women's basketball as 24.86 and 26.71 touches) are comparable to previous studies that reported test-retest reliability and/or normative reference values of the CKCUEST in both the original and modified test position. Although prior studies vary in start position, population, and scoring, results of the current study regarding test-retest reliability compared closely to studies conducted by Goldbeck and Davies in the original test position determining 27.8 touches as a test reference value in collegiate males and Tarara et al. in a modified test position determining an ICC of 0.73 in collegiate club sport athletes.[9] Test and retest means for both Saint Francis University's men's and women's basketball teams compared closely to normative reference values determined by Tucci et al. for active males and active females. Saint Francis University's men's basketball scores compared closely to reference values determined by Taylor et al. for male Division I athletes and Roush et al. for collegiate baseball players. However, Saint Francis University's men's basketball scores were higher when compared to reference values determined by Taylor et al. for men's basketball players. Women's scores compared closely to reference values determined by Taylor et al. specific to women's basketball players and female Division I athletes overall. Thus, results of the current study support the current evidence regarding the CKCUEST and its implementation in clinical practice to assess upper extremity function. In addition, results of the current study support the use of a modified test position as a measure to normalize the CKCUEST to body size, which may prove to be a useful alternative when administering the CKCUEST to injured and/or higher-level athletes.

Limitations

A small number of subjects were included in the study, and the CKCUEST as performed with the modifications in the start position may differ in how the athlete performs the reaching/returning task.

CONCLUSIONS

The results of the current study demonstrate that the CKCUEST in a modified test position is a reliable assessment tool. Using a modified testing position may be advantageous for athletes who are small in stature or have a narrow-shouldered body build. It may prove to be a useful alternative to the traditional test for assessing athletes in order to gain a representation of an athlete's abilities. The testing procedures used in the current study demonstrated consistent results compared to recent findings and established normative values specific to Division I collegiate athletes. The CKCUEST is easy to set up and administer, and may be used as an injury screen, to identify progress made in rehabilitation, and to assist in return to sport decision-making.

REFERENCES

1. Goldbeck TG, Davies GJ. Test-retest reliability of the closed kinetic chain upper extremity stability test: a clinical field test. *J Sports Rehabil*. 2000;9:35-45.
2. Oliveira VMA, Pitangui ACR, Nascimento VYS, et al. Test-retest reliability of the closed kinetic chain upper extremity stability test in adolescents: reliability of CKCUEST in adolescents. *Int J Sports Phys Ther*. 2017;12:125-132.

3. Davies GJ, Zillmer DA. Functional progression of a patient through a rehabilitation program. *Orthop Phys Ther Clinics North Am*, 2000;9:103-118.
4. Taylor JB, Wright AA, Smoliga JM, et al. Upper extremity physical performance tests in collegiate athletes. *J Sports Rehabil*. 2016;25(2):164-54.
5. Tucci HT, Martins J, Sposit GC, et al. Closed kinetic chain upper extremity stability test (CKCUES test): a reliability study in persons with and without shoulder impingement syndrome. *BMC Musculoskelet Disord*. 2014;15(1):1-9.
6. Tucci HT, Felicio LR, McQuade KJ, et al. Biomechanical analysis off closed kinetic chain upper extremity stability test. *J Sports Rehabil*. 2016;24:1-27.
7. Lee DR, Kim LJ. Reliability and validity of the closed kinetic chain upper extremity stability test. *J Phys Ther Sci.* 2015;27:1071-1073.
8. Sciascia A, Uhl TL. Reliability of strength and performance testing measures and their ability to differentiate persons with and without shoulder symptoms. *Int J Sports Phys Ther*. 2015;5:655-666.
9. Tarara DT, Hegedus EJ, Taylor JB. Real-time test-retest and interrater reliability of select physical performance measures in physically active college-aged student. *Int J Sports Phys Ther*. 2014;9:874-887.
10. Snyder J. Closed kinetic chain upper extremity stability test. John Snyder, DPT. https://johnsnyderdpt.com/for-clinicians/functional-testing/closed-kinetic-chain-upper-extremity-stability-test/. Accessed March 1, 2017.
11. Rousch JR, Kitamura J, Waits MC. Reference values for the closed kinetic chain upper extremity stability test (CKCUEST) for collegiate baseball players. *N Am J Sports Phys Ther*. 2007;2(3):159-63.
12. Botnmark I, Tumilty S, Mani R. Tactile acuity, body schema integrity and physical performance of the shoulder: a cross-sectional study. *Musc Sci Practice*. 2016;23:9-16.
13. Hegedus EJ, Vidt ME, Tarara DT. The best combination of physical performance and self-report measures to capture function in three patient groups. *Phys Ther Reviews*. 2014; 19(3):196-203.
14. Westrick RB, Miller JM, Carow SD, Gerber JP. Exploration of the Y-balance Test for assessment of upper quarter closed kinetic chain performance. *Int J Sports Phys Ther*. 2012;7:139-147.
15. Ellenbecker T, Manske RM Davies G. Closed kinetic chain testing techniques of the upper extremities. *Orthop Phys Ther Clin N Am*. 2000;9:219-229.
16. Pontillo M, Spinelli BA, Sennet BJ. Prediction of inseason shoulder injury from preseason testing in division I collegiate football players. *Sports Heath*. 2014;6:497-503.
17. Negrete RJ, Hanney WJ, Kobler MJ, et al. Reliability minimal detectable change, and normative values for tests of upper extremity function and power. *J Strength Cond Res*. 2010;24:3318-3325.
18. Negrete RJ, Hanney WJ, Kolber MJ, Davies GJ, Reinmann B. Can upper extremity functional tests predict the softball throw for distance: a predictive validity investigation. *Int J Sports Phys Ther*. 2011;6:104-111.
19. Davies GJ. The need for critical thinking in rehabilitation. *J Sports Rehabil*. 1995;4:1-22.
20. Borsa PA, Lephart SM, Kocher MS, Lephart SP. Functional assessment and rehabilitation of shoulder proprioception for glenohumeral instability. *J Sport Rehabil*. 1994;3:84-104.